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स्थिर पकड़ के साथ सतत् संचालन वाले मोनोकेबल रोपवे — रीति संहिता

(दूसरा पुनरीक्षण)

Continuous Movement Monocable Ropeways with Fixed Grips — Code of Practice

(Second Revision)

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Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, MED 06

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, had been approved by the Mechanical Engineering Divisional Council.

This standard was first published in 1969 and first revision was done in 1998. This revision has been undertaken to incorporate modifications based on the technology being followed in the country.

An aerial ropeway is a special form of transportation system where passengers/materials are carried on a tensioned wire rope supported above the ground. Aerial ropeways are particularly useful in regions where the facility in surmounting natural barriers gives them a great advantage over railways or roads, both of which may need the heavy civil engineering work to secure easy gradient. They are inexpensive to maintain; pollution free; environment friendly; does not affect aesthetics; their power demand is modest; and, they are not seriously affected by adverse climatic conditions.

Nothing in this standard is intended to contravene any provisions of the statutory regulations wherever they are in force.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CONTINUOUS MOVEMENT MONOCABLE ROPEWAYS WITH FIXED GRIPS — CODE OF PRACTICE

(Second Revision)

1 SCOPE

This standard covers the design and construction of continuous movement monocable aerial ropeways with fixed grips intended for the transportation of passengers and goods in separate vehicle.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 TERMINOLOGY

For the purpose of this standard, the following definitions in addition to those given in IS 7649 shall apply.

3.1 Monocable Fixed Grip Ropeway — A monocable ropeway system comprises basically an endless rope which acts both as the carrying as well as the haulage rope to which a number of carriages are attached at regular intervals. The carriages circulate around the close system by continuous carrying-*cum*-haulage rope. The carriages can be in the form of chairs or gondolas (enclosed carriers).

In fixed grip monocable ropeway, the carriages are fixed to the haulage/carrying rope and do not disengage during boarding/de-boarding operation.

3.2 Line — Route alignment of the ropeway between two terminals.

3.3 Inspecting Authority — Any competent authority recognized by the statutory regulations to inspect the aerial ropeways installation and determine its acceptability or otherwise, on the basis of this standard and compliance to prevailing statutory rules and regulations.

4 GENERAL REQUIREMENTS

4.1 Guidelines for Design and Construction

4.1.1 Each part of the ropeway equipment shall be designed and constructed in conformity with this standard. The quality of the materials to be used for its construction shall be as per the design.

4.1.2 On the request of the supervising authorities or the purchaser, a certificate of a recognized (NABL/ Statutory accredited) testing laboratory shall be supplied by the constructor as regards to the characteristics of material used and essential to the safety of the installation.

4.2 Route and Profile of the Line

4.2.1 As a rule, the axis of the line in its plan position shall be straight. However, horizontal deflections of the path of the travel may be permitted as regards supporting trestles provided that the minimum load on the roller train satisfies the requirements of **4.5.1** but with a minimum load of 2 kN, and that the angle of deflection does not exceed 0.5° (0.9 percent) per trestle.

4.2.2 The profile of the terrain chosen for constructing the installation and that of the line shall allow in the event of rescue of passengers, their safe descent by approved rescue system to ground as well as easy access to the nearest station.

4.2.3 The maximum slope of the loaded rope (that is, the load is uniformly distributed adjoining the rope itself) shall not exceed 100 percent.

4.2.4 The vehicles must be capable of passing over the trestles even in presence of inward and outward oscillation of 12° with minimum 0.5 m clearance without contact with tower structure.

4.2.5 In order to ensure the free movement of passengers and personnel in the station, the side clearance between the space occupied by a vehicle and fixed obstacles belonging to the installation shall not be less than 0.40 m measured towards the interior of the line. Such clearance shall be 0.5 m measured towards the outside of the line. In case there are no guides for vehicles, such clearance shall be maintained even when the vehicle is inclined transversally at 12°.

4.2.6 Along the line the distance between the two paths of travel of the carrying-hauling rope shall be such as to ensure a clearance of at least 1.0 m between vehicles swung by 12° towards one another. Such clearance shall be required for spans having a length of not more than

200 m. For longer spans; the clearance shall be increased by 0.20 m for each additional 100 m or fraction thereof.

4.2.7 A minimum clearance of 0.30 m between the space occupied by a loaded vehicle swung longitudinally by 15° and obstacles lying on the vertical longitudinal plane shall be ensured either along the line or in the stations.

4.2.8 The maximum height of the lowest portion of the vehicle from the ground, measured in the most unfavourable conditions, shall not be more than 8 m. However, if the height above ground is more than 25 m and such length is less than 20 percent of total ropeway, installation of vehicle will be allowed if a suitable designed and approved rescue cable pathway is provided below the chair where the vertical distance from cable path to underside of the chair is kept within 25 m or a independent rescue arrangement may be provided.

4.2.9 The minimum vertical clearance between the space occupied by a vehicle and the terrain lying below with obstacles existing over it, such as trees, rocks, snow drifts, etc, referred to the lowest outline of the vehicle shape and determined taking into account the most unfavourable conditions or assuming a conventional increase of 20 percent of the amount of static sag due to possible swing on account of braking and starting shall not be less than 2.5 m. Such limit however, may be reduced to 1.50 m in case of places inaccessible or forbidden to public and such places shall be cordoned off by fencing.

4.2.9.1 As regards with other communication paths or with aerial conductors, a minimum clearance shall exist in order to take into account requirements of **4.7**.

4.3 Maximum Speed and Minimum Spacing Between Vehicles

4.3.1 The maximum speed of the vehicle in the station shall not be more than 1.5 m/s.

4.3.2 The maximum speed of the vehicles along the line may reach 3 m/s provided that the acceleration or deceleration is not more than 0.3 m/s^2 and the variation of speed on account of the requirements of **4.3.1** does not give rise to dangerous oscillations of vehicles.

4.3.3 The minimum time spacing j seconds between passing of two successive vehicles shall be calculated by the expression $j = 4v$ for single-seat vehicles and $j = 7v$ for two or more seat vehicles, where v is the maximum speed in meter per second adopted for the installation.

4.4 Capacity and Type of Vehicles

4.4.1 The calculation of the various components shall be done, taking into account the weight of 80 kg per passenger.

4.4.2 Vehicles may have chairs for seating with maximum capacity of eight passengers.

4.4.3 Vehicles shall have sufficient dimensions for the passengers to be able to board and leave them easily and quickly.

4.4.4 The area at disposal of each passenger shall be at least 0.22 m².

4.5 Rope Guiding

4.5.1 The load exerted by the carrying-hauling rope on each supporting roller shall be not less than 350 N. However, the total load on each supporting roller train shall not be less than the value in kgf equal to the length in metres of the spans adjoining the trestle under consideration. This minimum load shall be respected under even the most unfavourable load conditions of the line and considering also effects due to starting and braking.

4.5.1.1 In case a trestle of the supporting type has its top under the straight line which links the top of the adjoining trestles, the load exerted by the rope shall satisfy not only the minimum values for each roller and roller train mentioned in **4.5.1** but shall be of such amount to ensure that in the most unfavourable load conditions and considering also the effects due to starting and braking, the rope does not come off the rollers even when there is an increase of tension equal to 30 percent.

4.5.2 The roller train shall be provided with a device, which, should the rope come off the roller, would cause the interruption of the safety and signalling circuit with the consequent immediate stopping of the motion of the entire system.

4.5.2.1 The roller train shall also be provided with guiding devices, which may prevent the rope from coming off towards the interior of the line. Such devices shall be preferably installed near the rollers situated at the end of the roller train.

4.5.3 The maximum load exerted by the carrying hauling rope on the rollers shall not be more than 200 kgf for each roller having the groove without soft material (such as rubber, neoprene rubber or aluminum) lining. If the groove has lining, the allowable load may be higher (for instance, as regards rubber of good quality, such load may reach the value of $4d \times D$, expressed in kgf when d is the diameter of the rope and D the diameter of the roller, are expressed in cm). The angle of deflection of the rope on each roller shall not be more than 2°30' for rollers without lining and 4°30' for rollers having soft material (such as rubber, neoprene rubber or aluminum) lining.

4.5.3.1 All rollers shall be mounted on rolling bearings. Rollers, with grooves lined with soft material (such as rubber, neoprene rubber or aluminum) shall preferably be used wherever possible.

4.6 Rescue of Passengers Along the Line

4.6.1 When designing an installation, suitable means for rescue shall be provided (ladders, Capstan, etc) to facilitate the rescue of passengers who might remain trapped along the line on account of unforeseen stopping of the installation in a reasonably short time and in the easiest and safest manner.

4.6.2 The chosen rescue equipment shall be such that the rescue operation can be carried out in a perfect manner even at the most critical points of the route (over water spread, rugged terrain, high elevation above ground, etc).

4.7 Crossings

4.7.1 The crossing of routes, railways, waterways or other ropeways shall be avoided as far as possible. Where it is not possible, the clearances shall be determined in such a manner that there is no danger for any vehicle using the various ways enumerated.

4.7.2 The crossings and paralleling with railways, highways, ropeways or overhead electrical lines shall be so done that no mutual discomfort results either in course of normal operation or rescue operation or during installation operations. Wherever the local conditions are favourable and the characteristics of the electrical line permit it, the overhead electrical lines shall be replaced by underground cables.

4.7.3 Long paralleling with electrical overhead lines or contact lines shall be avoided as far as possible. The distance of separation shall be determined in such a way that the safety of both the installations is assured. Any phenomenon of induction shall not, in any way, affect the continuity or integrity of the telephonic or safety systems on either of the installations.

4.8 Dangerous Areas

4.8.1 In the proximity of airports or in areas where airplanes fly at low altitude or land frequently, the route of the ropeways shall be adequately marked, taking into account any restriction imposed by the authority having jurisdiction over the airports.

4.8.2 The areas exposed to the dangers of natural, forces (avalanches, landslides, falling rocks, storms, earthquakes, etc) shall be avoided as far as possible.

4.8.3 If the dangers indicated in **4.8.2** exist, necessary protective devices shall be provided.

4.9 Wind Action

4.9.1 The wind forces and their effects (static and dynamic) should be taken into account when designing ropeways. The provisions mentioned in IS 875 (Part 3) and in IS 802 (Part 1) shall be followed

4.9.2 In the calculation of wind action on the cables, the surface area to be considered shall be the diametric surface of the cable multiplied by the factor

a) $C_w \approx 1.1$ for snow bound areas, and

b) $C_w \approx 0.7$ for areas not affected by snow.

4.9.3 The uplift caused by the breeze/wind on the wire rope and the carrier shall be considered with the conditions specified in **4.5.1** are fully met.

5 WIRE ROPES

5.1 General

5.1.1 As far as possible, all wire ropes shall be in single piece and of non-rotating construction. Welded joints in the rope shall be spaced at least 6 times the pitch of the wire and their number in 500 m length shall not exceed the number of wires in the wire rope.

5.1.2 In order to facilitate periodic in service checks the carrying-hauling rope should, preferably, be checked by a suitable non-destructive means like magneto-inductive test, to ensure that the requirement given in **5.8** is fully met.

5.1.3 The lubricants incorporated in the wire rope during manufacture or use, shall not exert any corrosive action on the material of the rope. The lubrication of the wire rope shall be done in conformity with a good established practice and according to particular requirements.

5.1.4 Care shall be taken to avoid any twisting or kinking of the rope while un-reeling the rope in service.

5.2 Carrying-Hauling Wire Rope

5.2.1 The wire rope conforming to IS 10891 (Part 1) shall be of stranded construction with a fiber core. The fiber core shall conform to IS 1804.

5.2.2 The minimum breaking load of the wire rope at the time of putting into service shall be not less than five times the maximum axial tension met with in service, calculated for the most unfavourable conditions which may occur by the combination of the following factors:

a) Counterweight;

b) Components of the ropeway and that of the loaded vehicles considered conventionally as uniformly distributed along the rope;

c) The frictional resistance in the tensioning device;
d) Resistance to motion exerted by the line rollers (in the case of rollers having their grooves lined with soft material, this value can be assumed to be 2.5 percent of the load on the rollers); and
e) Adequate amount of tension to limit the sag in the wire rope caused by its self-weight and load supported by it.

5.3 Tensioning or Regulating Ropes

5.3.1 The tensioning or regulating ropes shall be of round strand, ordinary lay type. Ropes of the Lang's lay type may be used only when the rotation of either the counterweights or the coupling to the carrying-hauling rope is prevented.

5.3.2 The nominal breaking strength of the tensioning or regulating ropes shall be at least 5.5 times the maximum axial load in the rope during operation.

5.4 Telephonic and Signal Cables

5.4.1 The telephonic and signal cables shall be of the stranded type and protected against corrosion.

5.4.2 The nominal breaking strength of the cables shall be not less than 3.3 times the maximum axial load met with in service.

5.4.3 Care shall be taken to ensure that the telephonic and signal cables do not come into contact either with the vehicles or with the carrying-hauling rope even under the worst conditions of weather. Therefore, if these cables are connected with line trestles, the height of the support shall be so chosen as to avoid any interference between the cables and vehicles or carrying-hauling ropes which can affect the safety and regularity of operation.

5.5 Loads and Pulley Diameter

5.5.1 *Direct Loads*

The weights supported by the grip of the vehicle to the carrying-hauling rope should not exceed one-twentieth of the minimum tension of the rope calculated for the most unfavourable conditions of load, but with the installation under normal conditions of operation.

5.5.1.1 As regards transverse loads transmitted by the line rollers on the carrying-hauling rope, the requirements of **4.5.3** shall also be satisfied.

5.5.2 *Sheaves*

5.5.2.1 To take into account the fatigue loads imposed on the carrying-hauling rope by permanent attachment of the vehicle, the diameter of the driving or return sheaves shall not be less than 100 times that of the wire rope and 1 000 times that of the outer wires of the wire rope. The sheave grooves shall be lined with soft material like Rubber/Neoprene rubber/Aluminum.

5.5.2.2 The deflection sheaves of the tensioning or regulating ropes of the stranded type shall have a diameter of not less than 40 times that of the tensioning rope and 600 times that of the diameter of the outer wires. Such sheaves shall be lined either with leather, wood or any other soft material.

5.5.2.3 The sheaves on which the tensioning or regulating ropes are normally stationary during the operation and the drums on which the regulating ropes are wound shall have a diameter of not less than 20 times that of the rope.

5.6 Splices and Rope Termination

5.6.1 All splices shall be made by experienced personnel. The length of a splice shall be not less than 1 300 times the rope diameter. The distance between two continuous splices shall be not less than 3 600 times the diameter of the rope.

5.6.1.1 Only one spliced joint along a closed loop formed by the carrying-hauling rope is desirable. However if the length of the ropeway exceeds 1 km, two splice joints may be permitted but even after repair of the rope after an accident, the total number of splice joints in the closed loop of the rope shall not exceed four splice joints.

5.6.2 Rope socketing shall be done with the utmost care. Only organizations who have experience of making of rope sockets shall be entrusted with this operation.

5.7 Testing and Acceptance of Ropes

The ropes used shall conform to the relevant Indian Standards.

5.8 Replacement of Ropes

Generally a rope should be withdrawn from service when it is considered that:

a) the loss of strength in the rope due to wear or corrosion or both is approaching one-sixth of the original strength.
b) the loss of strength in the rope due to fatigue, surface embrittlement or cracked and broken wires of any kind is approaching one-tenth of the original strength.
c) the outer wires have lost about one-third of their depth as a result of any kind of deterioration.

d) the outer wires are becoming loose and displaced for any reason.

e) the rope has become kinked, distorted or damaged and the damaged piece cannot be removed.

f) examination of the rope leaves any doubt as to its safety for any reason what-so-ever.

g) number of wires rupture in the rope exceed the limit specified in **8.1.6** of IS 3973**.**

6 STATIONS

6.1 General

6.1.1 According to the climate of the area where the ropeways are situated, suitable shelters for passengers and personnel shall be provided, as agreed by the buyer and the manufacturer. Such shelters shall conform to local statutory regulations.

6.1.2 The station machinery, such as mechanical parts of the driving gear, electrical equipment, ropes and vehicles shall not be a source of danger to the passengers and ropeway personnel. The passenger entrance shall not cross the path of the travel of the vehicles without ensuring proper safety to avoid any possible accident to the passengers.

6.1.3 The whole of the driving gear and of the return or deflection devices shall be protected against bad weather. Moreover, care shall be taken to prevent the entrance to the machine room of unauthorized persons to avoid any possible accident to them.

6.1.4 The ropeway operator shall be located where he shall have the best possible view of the route. The controls and communicating devices shall be within his reach without his having to leave his position.

6.1.4.1 The control panel shall be provided with the following:

a) Speed indicator; and

b) Fault indicator.

6.1.4.2 A speed control device which automatically stops the vehicle when the speed of vehicle approaching the station has not been suitably reduced shall be provided.

6.1.5 Fire hazard shall be reduced as far as possible. A sufficient number of extinguishers guaranteed to function effectively shall be kept ready in case of need and installed in places which are readily accessible.

6.2 Driving and Braking

6.2.1 The driving gear shall be provided with an emergency motor fed by auxiliary power or Internal Combustion engine which can ensure a rescue operation as needed even when there is something wrong with the main motor or even in case of power failure. However, installations having length less than 200 m winching device may be provided.

6.2.2 The speed of travel shall be maintained constant irrespective of any load conditions. In practice, the variation of the speed in the most unfavourable conditions shall not exceed 4 percent in case of an electrical motor and 5 percent in case of non-electrical drive.

6.2.2.1 In case the main motor is not of the electrical type and the installation is self-acting, a suitable dissipating device shall be provided to absorb the excess energy.

6.2.2.2 Starting under the most unfavourable conditions of load shall be guaranteed irrespective of type of drive used.

6.2.2.3 When the prime mover is 'not in action', the transportation of passengers is forbidden unless alternative full capacity prime mover can drive the ropeways.

6.2.2.4 In case the installation is of the self-acting type, the continuous braking shall be ensured by the driver, that is, the driver itself shall exert the braking action.

6.2.3 Working of the main, motor shall be stopped automatically when any brake is on or if any safety device operates.

6.2.4 *Rope Adhesion on the Driving Sheave*

6.2.4.1 The friction coefficients (μ) between the rope and the surface of the groove of the driving sheave are as follows:

a) Grooves with leather lining: $\mu = 0.15$

b) Grooves with rubber lining or with similar material having a high friction coefficient: $\mu = 0.25$

c) Grooves with aluminum liners: $\mu = 0.20$

6.2.4.2 For grooves with a special material lining a higher coefficient may be permitted for which value of μ to be agreed to between the ropeway promoter and the inspecting authority.

6.2.4.3 The contact angle of the rope on the driving sheaves shall be such as to ensure that in the most unfavourable combination of circumstance, the required power is transmitted to the rope.

6.2.5 As far as possible, belts shall not be used for power transmission. However, in the case of small powers (less than 10 HP) use of V-belts shall be permitted provided at least four belts are used simultaneously for transmitting the power.

6.2.6 Two different friction brakes with independent source of power shall be used in case of electric motor drive to cause both the normal stopping and emergency one. One of these brakes is called **'service brake' fitted on gearbox input shaft** and the other is **'emergency brake', fitted on drive sheave.** Each of such brakes shall be able to ensure the safe stopping of the installation's motion under most unfavourable conditions of loading. In any case, the nominal average deceleration shall not exceed 0.5 m/s^2.

6.2.6.1 In order to avoid any sudden braking with consequent violent swinging of the vehicles, it is recommended that the braking effort should be automatically proportional to the load conditions of the line or in a gradual manner.

6.2.6.2 The 'emergency brake' shall act directly on the driving sheave; springs shall induce its braking effort and its operation shall be carried out in a manner that its regular working can be automatically and constantly checked. This brake shall act automatically if the speed of the carrying-hauling rope exceeds the permitted value by 15 percent. It shall also be capable of being released manually. Emergency brake for ropeways on plain terrain may be deleted, if, the ropeways stops on its own without the application of an external brake.

6.2.6.3 The 'service brake', besides ensuring the holding of the driving gear when the installation is stopped, shall work when the feeding power fails or in case of overload of the ropeway. Moreover, it shall also work automatically when the remote control stops are activated or when any safety device is operated (*see* **6.2.3**).

6.2.6.4 The factor of safety of all parts forming the brakes shall not be less than 5.

6.2.7 A suitable automatic device which prevents the reverse motion of the system in normal service shall be installed. The reversal in, the direction of the movement shall not be possible except by intentional manipulation. This device as well as the safety brake is not obligatory when the installation is not self-acting even in case of a breakage of any element of transmission as also when one part of the rope is completely loaded and the other has no vehicle attached to it.

6.3 Rope Tensioning and Anchorage Devices

6.3.1 The carrying-hauling rope shall be kept under tension at one end, as constant as possible, using any of the following means:

a) Hydraulic tensioning devices; and
b) Counter weight.

In the case of hydraulic device, low elongation carrying-hauling rope shall preferably be used.

6.3.2 The spaces in which the counterweights travel (in pit or construction above the ground) shall be protected from water, snow, and ice and from any other material. It shall be ensured that the above elements do not accumulate inside these spaces. These spaces shall be provided with guard-rails in order to prevent the entrance of unauthorized persons.

6.3.3 The mobility of the tensioning devices shall be ensured at all times.

6.3.4 The travel of the counterweight shall be determined taking into account the maximum variation which may be due to the sag of each span, the surrounding temperature of the zone where the installation lies (minimum variation to be considered is 60°) and the elastic stretch of the rope.

6.3.5 All foundations shall be in accordance with IS 4091. For the structural safety against sliding, overturning and for the footings at different levels provisions laid down in IS 1904 shall apply. The depth of footings and other provisions shall conform to the provisions laid down in the relevant Indian Standards depending on the type of foundation [*see* IS 1904, IS 1080, IS 2950, IS 11089, IS 9456, IS 2911 (Part 1/Sec 1), IS 2911 (Part 1/Sec 2), IS 2911 (Part 1/Sec 3), IS 2911 (Part 1/Sec 4), IS 2911 (Part 3)].

6.3.6 For the structural safety against sliding, overturning and for the footings at different levels provisions laid down in IS 1904 shall apply.

6.3.7 Where several tensioning ropes are laid in parallel, all the necessary precautions shall be carried out in order to ensure uniform distribution of the tension among such ropes.

6.3.8 The foundations of either tensioning devices or the anchorage shall have a factor of safety of 1.5 in respect of shifting and over turning. Such factor of safety is to be calculated on the basis of a conventional assumption that these foundations are free, that is, there is no lateral movement of the earth.

6.4 Other Requirements

6.4.1 As regards the free movement of the vehicles in stations, the provisions of **4.2.5** shall be applicable.

6.4.2 Both the boarding and de-boarding sites shall preferably have a longitudinal gradient. In case of platform not being horizontal, the longitudinal gradient shall not exceed 10 percent. Moreover, the lowering of vehicles on account of their load shall be contained within allowable limits. The clearance to ground profile from the embarking area shall, preferably be increased, once the vehicle leaves the station.

6.4.2.1 According to the provisions of **6.4.2**, the boarding and de-boarding sites are those which are

situated in parts of the terrain in the horizontal position that is, in the part comprised between the end rollers of the first trestle, front of the station, and the rollers situated at the entrance and at the exit of the driving sheave. Being parallel to the carrying-hauling rope, the terrain situated within the above sites shall allow the boarding and de-boarding of passengers.

6.4.3 Push buttons and emergency stops of the system shall be installed at visible and approachable location of the terminal stations.

6.4.4 When skiers are to be transported, the length of boarding platform may be reduced to 2.5 m as long as it is followed with a safety space of at least 1.5 times the braking distance. Alighting platform may be also of same length but a descent (1:20) ramp may be provided at the end so that the passengers can quickly leave the area around the car.

6.4.5 The sheaves on which the carrying-hauling rope is supported shall be made of high quality cast iron, malleable cast iron, cast or fabricated steel. They shall be mounted on rolling bearings and shall be furnished with suitable devices, which can enable the rope to recover its normal position in case of derailment.

6.4.6 In stations, devices, which are integral part of the installation meant for fixation of the tackle, which enables the easy handling of wire ropes and the mechanical and electrical elements of the station, shall be provided. These devices shall be in a condition capable of being used at any time.

6.4.7 All suitable equipment for the inspection of the power elements shall be provided at least in one of the stations.

7 TRESTLES

7.1 Loads

In designing trestles, the following loads shall be considered:

a) The weight of the trestle and the pressure exerted by the ropes;
b) The whole of the stresses due to friction which occur during the motion of the carrying hauling rope. These stresses can be determined with a sufficient margin of safety as 2.5 percent of the load on the rollers;
c) Weight of vehicles traveling with maximum load (considered conventionally static);
d) Load due to wind and load of snow or ice (for wind action on the ropes, *see* **4.9.3**); and
e) Load imposed by communication cable, if provided.

7.1.1 The wind forces and their effects (static and dynamic) should be taken into account when designing ropeways. The provisions mentioned in IS 875 (Part 3), IS 802 (Part 1) shall be followed. Further, loads due to snow in accordance with IS 875 (Part 4) shall also be considered while designing ropeways. The ropeway design shall also consider seismic loads in accordance with IS 1893. In addition, other special loads in accordance with IS 875 (Part 5) shall also be considered while designing ropeway.

7.2 Safety

7.2.1 The metal parts of the trestle shall have a safety factor defined as the ratio of the ultimate strength of the metal to stress in the metal under the most unfavourable conditions of not less than 3.0 when the installation is in service.

7.2.2 The trestle shall be analyzed and designed for various load combinations as per IS 802. The trestle foundation shall be either a shallow foundation or deep foundation or founded on rock anchors. These foundations shall be in accordance with **6.3.5**.

7.2.3 For the structural safety against sliding, overturning and for the footings at different levels provisions laid down in IS 1904 shall apply.

7.2.4 The elastic deformation of the trestles, in particular those due to torsion which happens during normal conditions of operation, shall not be such as to endanger the safety of the guides and the stability of the ropes. The maximum angle of deformation due to torsion shall be limited in such a manner that the ends of the roller train for supporting the carrying-hauling rope are not displaced by more than 20 percent of the wire rope diameter.

7.3 Construction

7.3.1 The number of trestles, their position, their height and their construction are determined by the requirements of the route and the layout. Wooden trestles or trestles which are guyed, shall not be used.

7.3.2 In case the trestles have metallic framework, the thickness of the open profile shall be not less than 5 mm, while in the case of closed profile, it shall be not less than 2.5 mm. The interior of the latter shall be adequately protected against corrosion.

7.3.3 The anchorage of the trestles on the concrete foundations or on the rock shall be carefully made. The anchor bolts of concrete foundations shall just be above the ground.

8 VEHICLES

8.1 Factor of Safety

For all the components constituting the vehicle, the safety factor (ratio of the ultimate strength and stress in metal) shall be at least 5 under the static conditions. This factor of safety may have to be increased suitably to take into account the dynamic conditions to assure the desired degree of safety.

8.2 Construction

8.2.1 The vehicles shall be provided with a safety device which prevents the falling overboard of passengers and which conforms to the requirements of **4.4.2**. In the case of chair lifts having footrests, they shall be of the retractable type, which can be actuated, with the combined motion of the safety bar.

8.2.2 The hangers shall be of sufficient length as to guarantee conformity to the requirements of **4.2.4** to **4.2.6** and also ensure that roller guides, etc. are always outside the reach of the hand of the passengers.

8.2.3 The tubes used in the hangers shall have no longitudinal welds and preferably seamless. Their interior shall be protected against corrosion.

8.3 Grips

8.3.1 The form of grips used and the profile of the grooves of the line sheaves (over and under) and drive/return sheaves shall adapt to one another, and have flanges of adequate depth to prevent the haul rope from leaving the sheaves taking into account specially the maximum lateral swing permitted for the vehicles. The deflection of the rope caused by passing of the grips on the groove of the sheaves shall not be more than 9°.

8.3.2 The devices for attaching the vehicle to the carrying-hauling rope shall have a resistance with regard to its tendency to slide along the rope itself of not less than twice the component of the loaded vehicle weighed along the axis of the rope and considering maximum slope. Such minimum resistance shall be automatically ensured even if the diameter of the wire rope is reduced by 3 percent.

8.3.3 The distance between the sides of the jaws shall be such as to ensure an efficient gripping action of the grip on the rope even in the supposition that the diameter of the rope is conventionally reduced by one-tenth of the nominal diameter.

8.4 Numbering

In order to distinguish the vehicles on the line, they shall be successively numbered.

8.5 Lighting Equipment

Each vehicle shall be provided with relief lights.

9 COMMUNICATIONS, SAFETY CIRCUIT AND EARTHING OF METALLIC PARTS

9.1 Communications

9.1.1 The stations shall be linked to each other by telephone. At least one of the stations shall be linked up with the public network, wherever the latter exists.

9.1.2 Communication facilities (telephone or wireless) shall be provided in the vehicle for communication with the driving station or with the second vehicle. Other safety devices shall be provided for help in case of the failure of the telephone.

9.2 Safety Circuit

9.2.1 All the safety devices along the length of line and in the stations shall be incorporated in the continuous circuit energized permanently so that when any one device fails or the signal line fails, the system automatically comes to a halt.

9.3 Earthing

9.3.1 All the metallic portions of the installation with an exception of auxiliary ropes signal ropes, ballast and haulage ropes shall be directly earthed.

9.3.2 The entire ropeways system shall be provided with suitable protection against lightning.

10 SAFETY REQUIREMENTS

a) Two separate brakes shall be provided in the drive of ropeway system. One brake is provided on drive sheave. This will act as an emergency brake. A second brake is provided on high speed shaft which will act as service brake.

   The brakes must come in to operation automatically when:

   1) Normal Stop/Emergency Stop push button is pressed;
   2) The ropeway speed exceeds by 5 percent of the set speed;
   3) The tripping of drive motor due to actuation of line and station security devices; and
   4) In case of power failure.

b) Automatic working of the emergency brake is not required when the installation is not of the self-acting type even in the case of a breakage of any element of the transmission,

c) Arrangement should be made so that the brakes can be released during emergency running of the system.

d) Standby prime mover is required to run ropeway at slow speed, to rescue passengers from line in case of failure of main motor or power failure or DG set failure.

e) Line safety devices must be installed on each trestle and must immediately stop the ropeway in the unlikely event of rope derailment.

f) Rope catcher must be provided with the fully articulated sheave mount beam at incoming and outgoing side on line trestles and stations to arrest/support the hauling rope in case of de-ropement.

g) Emergency push buttons must be provided at all stations to stop the ropeway.

h) When skiers are to be transported, the length of boarding platform may be reduced to 2.5 m as long as it is followed with a safety space of at least 1.5 times the braking distance. Alighting platform may be also of same length but a descent (1:20) ramp may be provided at the end so that the passengers can quickly leave the area around the chair.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
802 (Part 1) : 2015	Code of practice for use of structural steel in overhead transmission line towers: Part 1 Materials, loads and permissible stresses,
(Sec 1) : 1995	Materials and loads
(Sec 2) : 1992	Permissible stress
875	Code of practice for design loads (other than earthquake) for buildings and structures:
(Part 3) : 1987	Wind loads
(Part 4) : 1987	Snow loads
(Part 5) : 1987	Special loads and load combinations
1030 : 1998	Carbon steel castings for general engineering purposes
1080 : 1985	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell)
1089 (Part 2) : 1986	Steel wire ropes for aerial ropeways — Specification : Part 2 Track ropes
1804 : 2004	Steel wire ropes-Fiber main cores — Specification
1893 : 1984	Criteria for earthquake resistant design of structures
1904 : 1986	Code of practice for design and construction of foundations in soils: General requirements
2062 : 2011	Hot rolled medium and high tensile structural steel
2911 (Part 1)	Code of practice for design and construction of pile foundations: Part 1 Concrete piles,
(Sec 1) : 1979	Driven cast *in-situ* concrete piles
(Sec 2) : 1979	Bored cast *in-situ* piles
(Sec 3) : 1979	Driven precast concrete piles
(Sec 4) : 1984	Bored precast concrete piles
2911 (Part 3) : 1980	Code of practice for design and construction of pile foundations: Part 3 Under-reamed piles
2950 (Part 1): 1981	Code of practice for design and construction of raft foundations: Part 1 Design
3973 : 1984	Code of practice for the selection, installation and maintenance of wire ropes
4091 : 1979	Code of practice for design and construction of foundation for transmission towers and poles
9456 : 1980	Code of practice for design and construction of conical and hyperbolic paraboloidal types of shell foundations
10891 (Part 1) : 2001	Steel wire ropes for aerial ropeways : Part 1 Haulage ropes
11089 : 1984	Code of practice for design and construction of ring foundation
14329 : 1995	Malleable iron castings

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee, MED 06

Organization	*Representative(s)*
RITES Limited, Gurgaon	Shri Rajiv Milind (***Chairman***)
Central Institute of Mining and Fuel Research (CIMFR), Dhanbad	Shri Debasis Basak Shri Girendra M. Prasad (*Alternate*)
Conveyor Ropeway Services Pvt Ltd, Kolkata	Shri S. Shekhar Chakravarty Shri Kamal Kumar Bose (*Alternate*)
Damodar Ropeways and Infra Ltd, Kolkata	Shri Ranjan Mukherjee
Directorate General of Mines Safety, Dhanbad	Shri D. B. Naik Shri Vijay Kumar K. (*Alternate*)
Directorate General Factory Advice Service and Labour Institute, (DGFASLI), Mumbai	Shri U. K. Das Shri H. Chattopadhyay (*Alternate*)
Elecon Engineering Co Ltd, Vallabh Vidyanagar	Shri C. S. Shah Shri K. S. Kodia (*Alternate*)
Indian Association of Amusement Parks & Industry, New Delhi	Shri Pradeep Sharma Shri Balwant Chawla (*Alternate*)
Mcnally Bharat Engineering Co Ltd, Kolkata	Shri Shyamal Kumar Das Shri Ashoke Kumar Bose (*Alternate*)
MECON Limited, Ranchi	Shri A. K. Ghosh Shri jaipal singh (*Alternate*)
Ministry of Shipping New Delhi	Shri B. Poiyaamozhi Shri D. J. Basu (*Alternate*)
National Mineral Development Corporation Ltd, Hyderabad	Shri B. Chandra Shri R. M. R. Kramnath (*Alternate*)
National Thermal Power Corporation Ltd, New Delhi	Shri O. P. Kalia Shri B. K. Bhattacharya (*Alternate*)
Phoenix Conveyor Belt India (P) Ltd, New Delhi	Shri Rajeev Sharma Shri Asoke Kumar Ghosh (*Alternate*)
Polo amusement Park Ltd, Gurgaon	Shri Santosh Chawla
Projects and Development India Ltd, Dhanbad	Shri Narendra Singh
Rail India Technical and Economic Services Ltd, (RITES), Gurgaon	Shri A. Bhadra Shri N. C. Srivastava (*Alternate*)
Ropeway and Resorts Pvt. Ltd, Kolkata	Shri A. K. Kinra
Steel Authority of India Ltd (IPSS SECT), New Delhi	Shri S. K. Bose Shri R. K. Anand (*Alternate*)
USHA BRECO Limited, Ghaziabad	Shri Sanjeev Dhariwal Shri Manoj Panwar (*Alternate*)
In personal capacity (*145/4A, South Sinthi Road, Kolkata-700050*)	Shri C. K. Karmakar
In personal capacity (*F-7B, DDA MIG Flats, Hari Nagar, New Delhi-110006*)	Shri S. C. Gandhi
BIS Directorate General	Shri A. Renga Rajan, Scientist 'E' and Head (MED) [Representing Director General (*Ex-officio*)]

Member Secretary
Shri A. K. Mohindroo
Scientist 'C' (MED), BIS

Panel 1 on Aerial Ropeways

Organization	*Representative(s)*
RITES Limited, Gurgaon	Shri A. Bhadra (***Convener***)
CIMFR, Dhanbad	Dr D. Basak
Conveyor & Ropeway Services Pvt Ltd, Kolkata	Shri K. K. Bose
DGMS, Kolkata	Shri D. B. Naik
Damodar Ropeways and Infra Ltd, Kolkata	Shri Ranjan Mukherjee

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